<u>IN THE UNITED STATES PATENT AND TRADEMARK OFFICE</u>

APPLICATION FOR UNITED STATES PATENT

SMARTBRIDGE FOR TACTICAL NETWORK ROUTING APPLICATIONS

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SMARTBRIDGE FOR TACTICAL NETWORK ROUTING APPLICATIONS

BACKGROUND OF THE INVENTION

Field of the Invention (Technical Field):

The invention relates to datalink communications for aircraft, spacecraft, surface vehicles, and ground-based communications infrastructures, and more particularly to a method and apparatus for an intelligent communications capability that enhances legacy military tactical datalink systems by creating an interface between disparate civil and military communications systems.

Background Art:

Each military tactical datalink radio is an independent system and was not designed with the idea of integrating with other radio systems. In the past use of an external communications management router for military tactical datalink radios had not been developed. Until recently, the military was focused on specific tactical radio point solutions rather than an integrated solution.

The military is in the process of addressing requirements in order to use civil airspace, and at the same time is developing and expanding tactical radios and datalink systems to use in the digital battlefield. Unfortunately, the Radio Frequency (RF) spectrum, communications radio equipment, and message protocol requirements used in civil airspace operations [civil satellite radios, Very High Frequency (VHF) radios, High Frequency, (HF) radios, and wireless systems] are different from those used in digital battlefield operations [military satellite radios, Ultra High Frequency (UHF) radios, and HF radios]. This is further complicated by constraints on some military tactical aircraft and ground vehicles that only have tactical datalink systems with no provisions for the installation and use of civil communications equipment. Military ground-based communications infrastructures also lack the integration with civil infrastructures that could provide exchange of data between these systems.

Datalink communications include RF radio equipment operating in various frequency ranges (i.e. UHF, VHF, HF), as well as the associated communications networks and protocols [i.e. Aircraft Communications Addressing and Reporting System (ACARS), Aeronautical Telecommunications Network (ATN), Link-16]. Both civil datalink radios [i.e. Inmarsat Satellite Communications (SATCOM), VHF, HF] and military tactical datalink radios [i.e. Military Strategic, Tactical and Relay (MILSTAR)

SATCOM, Multifunction Information Distribution System (MIDS), Joint Tactical Information Distribution System (JTIDS)] are used.

Currently, the typical military aircraft is equipped with several independent communications systems. The aircraft crew must interface directly with each communications system and the integration of data link information between each system must be manually processed by the crew. Types of communication systems the crew must interact with are UHF/VHF line of sight radios, HF long-range radios, military satellite communications equipment, civil satellite communications equipment, and the JTIDS/MIDS communications equipment. As civil telecommunications technologies evolve, data link communications will continue to expand and the aircraft crew workload and efficiency make it necessary to integrate these disparate communication systems and automate more routine tasks at multiple locations using a diverse range of equipment.

Currently, each military tactical datalink radio system is operated independently of other civil or military systems. Exchange of information between systems is performed manually or not at all. The Civil Communications Management Unit (CMU) specified by Aeronautical Radio, Inc. (ARINC) specification number 758, integrates three civil datalink radio systems (Inmarsat SATCOM, VHF, and HF) but does not interface with any military datalink radio systems.

ARINC and Viasat demonstrated sending a military Link-16 message through the ACARS ground-based communications infrastructure. This was accomplished by using a Link-16 radio in an aircraft to communicate with a Link-16 radio installed in the ground-based communications infrastructure and then routing the link-16 message to its destination over phone lines. In actuality, they did not route the Link-16 message through another datalink radio system.

The Air Force Research Laboratory (AFRL) at Rome, NY installed several different datalink radio systems in a pallet and put the pallet in a KC-10 aircraft. The purpose of this demonstration was to receive multi-media information over several different air-ground networks while airborne. They did not route messages intended for one datalink system through another datalink system. Civil and military datalink systems operated independently from one another in this demonstration.

Each of these prior art systems are deficient because: communications management of military tactical networks (JTIDS, MIDS, and MILSTAR) is not integrated with civil networks (Inmarsat SATCOM, VHF, and HF); messages normally intended for transmission over a military tactical network can not be re-routed over one of several civil networks; messages normally intended for transmission over a civil network can not be re-routed over one of several military networks; message routing criteria

based on priority, security, urgency, message size, and transmission bandwidth is not integrated for all available civil and military communications systems as a whole; data collection agents are not implemented to compute an integrated actual communications performance indicator; data collection agents are not used to collect mission data available from tactical datalink messages needed for Air Traffic Control (ATC) messages; and data collection agents are not used to collect mission data available from tactical datalink messages needed for Aeronautical Operational Control (AOC) messages.

None of the prior art systems creates a software or hardware solution that provides an intelligent bridge between disparate vehicle and ground-based communications systems.

SUMMARY OF THE INVENTION (DISCLOSURE OF THE INVENTION)

SmartBridge will interface with tactical datalink applications and service support applications used by the military and manage associated transport, network, link, and physical layers needed to interface with the military communications systems (JTIDS, MIDS, and MILSTAR), and other avionics devices and end systems. Additionally, SmartBridge will offer the military the capability to bridge between military and civil communications systems allowing messages to be routed transparently across all available systems. For example, a Link-16 message could be routed over a civil VHF

radio system in the event that the Link-16 radio is failed or unavailable. Likewise, the Link-16 tactical radio could be used to route ATC messages in the event that civil radio [Satellite Date Unit (SDU), VHF Data Radio (VDR), or High Frequency Data Radio (HFDR)] fail or are unavailable. For aircraft and spacecraft applications, the SmartBridge function can be implemented in a standalone hardware unit, or as a software application in an on-board computer system, that interfaces with onboard communications systems.

For surface vehicle applications, the SmartBridge function can be implemented in a standalone hardware unit, or as a software application in an on-board computer system, that interfaces with onboard communications systems. SmartBridge will provide enhanced communication network management onboard the vehicle along with data routing to other systems. Data collection agents can be used to extract information from internal equipment or extract information from other onboard messages for reporting.

For ground-based communications infrastructures, the SmartBridge function can be implemented as a software application in a computer system that interfaces with various communications networks. SmartBridge enables ground stations to interpret data from either civil or military datalink systems, and can provide a communications medium to decipher and route data to the respective ground network. This will enable military ground stations

receiving data to handle civil communications messages or route data from military communications messages to civil ground networks.

By addressing all applications (aircraft, spacecraft, surface, and ground-based), the SmartBridge function can provide interfaces between military and civil communications systems and bring previously non-connected networks together for enhanced interactions. Additionally, communications networks requiring interaction with data in other stove-piped networks can use SmartBridge to perform advanced data routing to these disparate networks.

A primary objective of the present invention is to provide a method and apparatus for performing new and unique functions for the military integrating both civil and military communications requirements.

Another objective of the present invention is to make it easier for the military to get real-time data when they want it and where they want it.

Yet another objective of the present invention is to provide a system that integrates data link information within military aircraft avionics and ground vehicle computer architectures.

Another objective of the present invention is to provide a system to transmit and process a variety of different types of data link messages originating from or sent to disparate civil and military communication systems onboard an aircraft and ground vehicle as well as providing military interfaces to civil ground-based communications infrastructures.

Another objective of the present invention is the establishment of message routing instructions using common criteria for both military and civil messages.

A primary advantage of the present invention is to provide a system to manage the integration, configuration, and status of all available civil and military communications systems.

Another advantage of the present invention is the reduction of vehicle crew workload by integrating communications datalink equipment and automating message routing decisions.

Yet another advantage of the present invention is the improvement of the overall operational efficiency of the military through intelligent information management and message handling flexibility across all available communications networks.

Another advantage of the present invention is the ability of the system to be applied to information management and message handling for commercial transportation businesses (airlines, trucking, trains, ships, etc.)

Yet another advantage of the present invention is the system's intelligent applications using learning techniques to improve the overall efficiency of integrated military missions, operations, and maintenance activities.

Other objectives, advantages and novel features, and further scope of applicability of the present invention will be set forth in part in the detailed description to follow, taken in conjunction with the accompanying drawings, and in part will become apparent to those skilled in the art upon examination of the following, or may be learned by practice of the invention. The objectives and advantages of the invention may be realized and attained by means of the instrumentalities and combinations particularly pointed out in the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated into and form a part of the specification, illustrate several embodiments of the present invention and, together with the description, serve to explain the principles of the invention. The drawings are only for the purpose of illustrating a

preferred embodiment of the invention and are not to be construed as limiting the invention. In the drawings:

Fig. 1 is a system context diagram for the SmartBridge function.

Figs. 2a and 2b are a two part flow chart illustrating the SmartBridge functional flow.

DESCRIPTION OF THE PREFERRED EMBODIMENTS (BEST MODES FOR CARRYING OUT THE INVENTION)

The present invention creates a software or hardware solution that provides an intelligent bridge between disparate vehicle and ground-based communications systems.

Fig. 1 illustrates how the SmartBridge function can fit into a layered architecture. In this context the SmartBridge function becomes an interface layer between applications (on top) and various network layers defined by the International Standards Organization (ISO) and Open Systems Interconnection (OSI) standard (i.e. transport, network, link, and physical) layers used to interface with different communications systems. With this layered architecture, the SmartBridge function can be implemented in systems on aircraft, spacecraft, and surface vehicles as well as in ground-based communications infrastructures to intelligently integrate each together into a global communications network.

As shown in Fig. 1, the SmartBridge **160** is layered with software applications **100, 110, 120, 130, 140**, and **150** and functions **170** through **245**, that can be executed in aircraft, spacecraft, surface vehicle, and ground-based computer systems. These software applications **100** through **150** and functions **170** through **245** are layered in accordance with the OSI Layers **250**. The OSI standard defines seven layers as application **251**, presentation (not shown), session (not shown), transport **254**, network **255**, link **256**, and physical **257**. Presentation and session layers are either not used or are incorporated by the software applications as required. External interfaces **258** through **295** are used by these software applications **100** through **150** and functions **170** through **245**. These software applications **100** through **150** and functions **170** through **245** could be implemented in a stand-alone box (an example is defined in ARINC specification number 758) and execute on processors within this box. These same software applications **100** through **150** and functions **170** through **245** could also be executed in other computer equipment where processor resources and communications interface hardware is available.

One example of how SmartBridge **160** could be applied is to expand the data communications capabilities in today's military fighter aircraft. The current data communications capability of a fighter aircraft is designed for tactical operations and is very limited in its ability to use civil datalink air-ground communication networks. Fighter aircraft typically use the Link-16

radio system. The Link-16 radio system today only interfaces with military air-ground communications networks and only exchanges information with other military aircraft equipped with Link-16 radios and military command and control centers. Incorporating SmartBridge **160** into fighter aircraft will provide the capability to bridge between military and commercial air-ground communications networks. This will allow information on the fighter aircraft to be exchanged with commercial air-ground networks in addition to the military air-ground networks. This added capability will allow exchange of information with civil ATC centers as well as with other military organizations such as operational and maintenance organizations. To accomplish this, SmartBridge **160** and the civil communications management functions (**120** through **150**, **170**, **175**, **185** through **215**, and **230** through **245**) can be implemented as software layers within an existing mission computer on the fighter aircraft. Additional software layers can also be implemented in the mission computer to provide military unique software applications (**100** and **110**) and military unique functions (**180**, **220** and **225**) that are associated with fighter aircraft datalink operations. The mission computer provides access to the external military interfaces on the fighter aircraft (**275** through **285**).

For this example it is assumed that the fighter aircraft does not contain any civil communications radios or end systems or the associated external interfaces (**258** through **270**) to the mission computer. It is also

assumed that the fighter aircraft does not contain any future military end systems or the associated external interfaces (**290** and **295**) to the mission computer. SmartBridge **160** can support these civil radios and end systems and future military end systems if and when they are added to the fighter aircraft in the future.

Using this example, SmartBridge **160** provides the following capabilities to expand the data communications capabilities in today's military fighter aircraft:

1. SmartBridge **160** determines which military end systems **275** are connected to the mission computer and the health of those end systems. SmartBridge **160** determines which military communications radios are connected to mission computer (**280** and **285**) and the health of those communications radios. By determining the type of radio (JTIDS, MIDS, or MILSTAR) SmartBridge **160** knows what communications network **180** to use and the link layer (**220** or **230**) and physical layer (**225** or **235**) protocols that will apply. SmartBridge **160** determines the status and performance capability of the available military radios and computes the Actual Communications Performance (ACP) indicator. The ACP and any network faults are recorded in memory to be used in making subsequent message routing

decisions. This general process is illustrated in Fig. 2a **310** through **335**.

2. SmartBridge **160** executes its data collection agents to monitor available end systems **275** on the fighter aircraft. These data collection agents also interface with military software applications **100** and **110** to collect tactical and mission data. In this example engine data and end system status and faults are collected from available end systems **275**, and aircraft position and navigation data is collected from tactical datalink applications **100**. SmartBridge **160** analyzes the engine data and end systems status and faults looking for trends, maintenance decision aids, and alerts for the pilot. This general process is illustrated in Fig. 2a **395** through **430**.

3. SmartBridge **160** sends the collected data to civil communications management applications **120** through **150** where they are formatted into an engine parameter report, maintenance data report and a position report. Civil communications management applications **120** through **150** also schedule the position report to be sent to the current ATC center, and the engine parameter report and maintenance data report are scheduled to be sent to the military AOC for the fighter aircraft. These scheduled reports

are properly formatted to include the appropriate destination address and then sent to SmartBridge **160** to be transmitted over the available communications network.

4. SmartBridge **160** analyzes the type of reports to be sent and determines their routing criteria. Each individual report is processed according to its routing criteria and routing instructions are prepared. This general process is illustrated in Fig. 2a **345** through **385**.

5. SmartBridge **160** uses the current network configuration and status information and message routing instructions to determine the exact message routing. For this example the JTIDS radio terminal **280** will be used to transmit the position report because it has a high priority. The MILSTAR radio terminal **285** is selected to transmit the engine parameter report and maintenance data report on a low priority basis. This general process is illustrated in Fig. 2b **445** through **495**. SmartBridge **160** uses the appropriate network layer **180**, link layer **220**, and physical layer **225** to transmit each message to either the JTIDS radio terminal **280** or the MILSTAR radio terminal **285**.

6. In this example the civil air-ground communications network on the ground contains a JTIDS compliant Link-16 radio terminal and receives the position report transmitted by the JTIDS Link-16 radio terminal on the fighter aircraft. The civil ground station equipment also contain SmartBridge **160** functions and civil communications management functions (**120** through **150**, **170**, **175**, and **185** through **215**) implemented as software layers and it's own link and physical layers. Using SmartBridge **160** functions and civil communications management functions (**120** through **150**, **170**, **175**, and **185** through **215**), the civil ground station equipment determines that the position report is intended for the ATC center and sends it to the proper ATC system.

7. The engine parameter report and maintenance data report transmitted from the fighter aircraft's MILSTAR radio terminal is received by the MILSTAR communications system. The associated MILSTAR ground station equipment contain SmartBridge **160** functions and civil communications management functions (**120** through **150**, **170**, **175**, and **185** through **215**) implemented as software layers and it's own link and physical layers. Using the SmartBridge **160** function and civil communications management functions (**120** through **150**, **170**, **75**, and **185** through **215**), the MILSTAR ground station equipment

determines that these reports are intended for the fighter aircraft AOC and send them to the proper military AOC system.

8. The same general process in reverse can be used on the fighter aircraft to receive incoming messages sent from the civil or military air-ground communications networks. In this case SmartBridge **160** receives messages from the available communications radios **280** and **285** and analyzes them to determine where to send them using instructions contained in each message. SmartBridge **160** sends civil messages, such as ATC or AOC messages, to the appropriate civil communications management software application **120** through **150**. SmartBridge **160** sends military messages, such as Link-16 mission information, to the appropriate military software applications **100** and **110** or requested end systems **275** on the fighter aircraft. SmartBridge **160** also executes its data collection agents to monitor these incoming messages and collects information as required. SmartBridge **160** intelligently routes this collected information to software applications (**100** through **150**) and end systems **275**.

This fighter aircraft example illustrates how SmartBridge **160** processes and routes both civil messages (ATC and AOC) as well as military messages (Link-16 mission information) over the available JTIDS/MIDS

radio terminals **280** and MILSTAR radio terminals **285**. The fighter aircraft could contain a civil communications radio such as a VDR **258**, or a SDU, HFDR or Mode S **260**. In this case SmartBridge **160** would process and route both civil messages (ATC and AOC) as well as military messages (Link-16 mission information) over the available VDR **258** and SDU, HFDR or Mode S **260** as required.

The definitions and applications of the elements of Fig. 1 are described as follows.

Tactical datalink applications **100** (i.e., Link-16, others) represents military software applications that use and/or generate mission data that is received from and/or sent to other systems or over available datalink networks.

Service support applications **110** represent software applications that provide services and/or support to tactical datalink applications **100** and the SmartBridge function **160**.

Datalink Management (DM) **120** represents software applications that provides datalink management for avionics end systems in accordance with ARINC specification number 656. DM **120** is a standard civil datalink

application and is used only when an ARINC specification number 656 network path **185** is available.

ATN MGMT **130** represents software applications that provide ATN message management (MGMT) **130**. This is an emerging civil datalink application that is currently being developed. These applications will use ATN protocol functions when available to interface with external civil communications equipment and other devices and end systems (**258** through **270**). These protocol functions are Transport Protocol 4 (TP4) **195**, Connection Less Network Protocol/Router Protocol (CLNP/RP) **200**, 8208 **205**, and 8208 Aviation Packet (AVPAC) **210** and associated link layers **230**, **240** and physical layers **235**, **245**.

A623 **140** represents software applications that generate ATC messages in accordance with ARINC specification number 623. A623 **140** is a standard civil datalink application and is used when ARINC specification number 623 messages are required.

AOC **150** represents software applications that generate AOC messages in accordance with ARINC specification number 702A flight management system AOC andARINC specification number 620. AOC **150** applications are standard civil datalink applications that interface with end

systems and route these AOC messages to and from end systems and available communications equipment.

SmartBridge **160** processes transmit message requests received from each application (**100** through **150**) to determine the message routing criteria **340** of Fig. 2a and selection of the appropriate network path (**170** through **215**) to use in transmitting the message. SmartBridge **160** also processes messages received from each of the available network paths (**170** through **215**) using the message handling processes **470** of Fig. 2b, to determine which application (**100** through **150**) each received message is to be sent to. In this manner SmartBridge **160** manages the message routing decisions so that applications (**100** through **150**) do not need to be concerned about which network path to use.

An example of the benefit SmartBridge **160** provides to the military can be illustrated with the AOC **150** application. In the civil environment AOC messages only use the A618 **215** network path or the ATN network path (**195** through **210**) for sending and receiving AOC messages using civil datalink radios **258, 260**. SmartBridge **160** will also use the tactical network path **180** to send and receive AOC **150** messages. By using the tactical network path **180**, SmartBridge **160** can send and receive AOC **150** messages using the JTIDS/MIDS datalink radio terminals **280** or the MILSTAR datalink radio terminals when they are available. SmartBridge **160**

uses the necessary decision processes **440** and message handling processes **470** to format AOC messages for transmission over the selected network path and to decode AOC messages received over each network path. Since the SmartBridge function **160** is implemented in both the vehicle equipment as well as the ground systems equipment, these decision processes **440** and message handling processes **470** ensure that each message is properly handled and distributed to the intended application(s). The process used to handle AOC messages described in this example is the same process that will be used for the other applications (**100** through **140**).

TP4 **195** represents software functions that implement the OSI transport layer protocols for the ATN network path. TP4 **195** is defined by the International Civil Aviation Organization (ICAO) ATN specification.

A619 **170**, **190** represent software functions that implement the OSI network layer protocols for communications with end systems in accordance with ARINC specification number 619. A619 **170** implements A619 protocols using Military Standard 1553B (MIL-STD-1553B) link **220** and physical **225** layers. A619 **190** implements A619 protocols using ARINC 429 or Ethernet link **230** and physical **235** layers.

A656 **175, 185** represent software functions that implement the OSI network layer protocols for communications with a flight management

system in accordance with ARINC specification number 656. A656 **175** implements A656 protocols using MIL-STD-1553B link **220** and physical **225** layers. A656 **185** implements A656 protocols using ARINC 429 or Ethernet link **230** and physical **235** layers.

TACNET **180** (Tactical Network Router) represents software functions that implement the OSI network layer protocols for tactical networks. The TACNET **180** network layer protocols function **180** uses various link layers **220**, **230** and physical layers **225**, **235** to interface with the various military tactical communications systems and associated end systems **275** through **295**.

CLNP/RP **200** represents software functions that implement part of the OSI network layer protocols for the ATN network path. CLNP/RP **200** is defined by the ICAO ATN specification.

Element 8208 **205** represents software functions that implement part of the OSI network layer protocols for the ATN network path. 8208 **205** is defined by the ICAO ATN specification.

Element 8208 AVPAC **210** represents software functions that implement part of the OSI network layer protocols for the ATN network path. Element 8208 AVPAC **210** is defined by the ICAO ATN specification.

A618 **215** represents software functions that implement the OSI network layer protocols for communications with various air-ground networks in accordance with ARINC specification number 618.

MIL-STD-1553 LINK **220** represents software functions that implement the OSI link layer protocols for network paths that interface with equipment using MIL-STD-1553B interfaces.

MIL-STD-1553 PHYSICAL **225** represents software functions that implement the OSI physical layer protocols for communication with MIL-STD-1553B controllers.

NEW LINK & A429 WILLIAMSBURG PROTOCOLS **230** represents software functions that implement the OSI link layer protocols for network paths that interface with equipment using Ethernet or ARINC specification number 429 interfaces.

HS PHYSICAL/A429 **235** represents software functions that implement the OSI physical layer protocols for communication with Ethernet controllers or ARINC specification number 429 High Speed (HS) controllers.

A429 WILLIAMSBURG PROTOCOLS **240** represents software functions that implement the OSI link layer protocols for network paths that will interface with equipment using standard ARINC specification number 429 interfaces.

A429 **245** represents software functions that implement the OSI physical layer protocols for communication with standard ARINC specification number 429 controllers.

END SYSTEMS **275** represents interface systems that the SmartBridge function **160** will communicate with. FUTURE END SYSTEMS **290** represents growth for future systems that the SmartBridge function **160** will communicate with.

JTIDS/MIDS TERMINALS **280** represents JTIDS and MIDS radio terminal equipment that TACTICAL DATALINK APPLICATIONS **100**, SERVICE SUPPORT APPLICATIONS **110**, and military end systems **275**, **290** communicate with.

MILSTAR TERMINAL **285** represents MILSTAR satellite radio terminal equipment that TACTICAL DATALINK APPLICATIONS **100**, SERVICE SUPPORT APPLICATIONS **110**, and military end systems **275**, **290** communicate with.

VDR **258** represents civil VDR equipment that applications **100** through **150** and end systems **265**, **270**, **275** or **290** communicate with.

SDU, HFDR, MODE S **260** represents civil SDU equipment, HFDR equipment, or Mode S transponder equipment that applications **100** through **150** and end systems **265**, **270**, **275** or **290** communicate with.

HS A429 ENABLED DEVICES & END SYSTEMS **265** represents equipment that applications **100** through **150** communicate with that are connected to ARINC specification number 429 HS system buses.

ETHERNET ENABLED DEVICES & END SYSTEMS **270** represents equipment that applications **100** through **150** communicate with that are connected to ethernet system buses.

Fig. 2 illustrates the SmartBridge functional flow in Fig. 2a and Fig.2b, and is organized into four major sections:

Network Configuration and Status **305**,

Message Routing Criteria **340**,

Data Collection Agents **390**, and

Network Management and Message Distribution **435**.

START **300** illustrates the beginning of the functional flow. SmartBridge processes being described are repetitive and will be executed at a pre-defined rate.

Section 1 **305** illustrates the NETWORK CONFIGURATION AND STATUS function. DETERMINE NETWORK CONFIGURATION AND STATUS **310** interfaces with all available civil and military communications systems to determine their configuration and operational status. The results are then placed as stored data in AVAILABLE NETWORKS & STATUS **315**. GENERATE NETWORK FAULT MESSAGE **320** uses information received from each communications network to identify communications system faults and updates NETWORK FAULTS **325** with current fault status. Using AVAILABLE NETWORKS & STATUS **315** and NETWORK FAULTS **325**, COMPUTE ACTUAL COMMUNICATIONS PERFORMANCE **330** assesses overall capability and health of available communications systems and computes a current ACP indicator and updates ACP **335** with results.

Section 2 **340** illustrates the MESSAGE ROUTING CRITERIA function. MESSAGE REQUEST **345** determines if a request has been submitted to receive or transmit a message. If a request is active, then several processes **350**, **360**, **370**, and **380** are performed to evaluate routing criteria and to prepare instructions for the NETWORK MANAGEMENT AND MESSAGE DISTRIBUTION function in section 4 **435**. EVALUATE

PRIORITY CRITERIA **350** assesses message priority constraints and updates PRIORITY PROCESSING INSTRUCTIONS **355** with routing instructions. EVALUATE SECURITY CRITERIA **360** assesses message security constraints and updates SECURITY PROCESSING INSTRUCTIONS **365** with routing instructions. EVALUATE URGENCY CRITERIA **370** assesses message urgency constraints and updates URGENCY PROCESSING INSTRUCTIONS **375** with routing instructions. EVALUATE SIZE/BANDWIDTH CRITERIA **380** assesses message size and bandwidth constraints and updates SIZE/BANDWIDTH PROCESSING INSTRUCTIONS **385** with routing instructions.

Section 3 **390** illustrates the DATA COLLECTION AGENTS function as a series of processes **395**, **405**, **415**, and **425**. PROCESS AGENTS TO COLLECT END SYSTEM DATA **395** scans messages received from various end systems interfaced to the SmartBridge function **160** and extracts data of interest. Data extracted is saved in END SYSTEM DATA **400**. ANALYZE DATA FOR TRENDS **405** scans current values of END SYSTEM DATA **400** with previous values collected over a selectable time interval and identifies trends for specific data items, for example engine parameter trend data. Any trends of significance are saved in TRENDS **410**. ANALYZE TRENDS & UPDATE DECISION AIDES **415** scans trend values in TRENDS **410** and evaluates threshold criteria established for decision points. DECISION AIDES **420** is updated with results from this analysis. GENERATE

AUTOMATIC ALERTS **425** evaluates decision aides and generates alerts (saved ALERTS **430**) to be distributed to pre-defined military agencies and organizations.

Section 4 **435** illustrates the NETWORK MANAGEMENT AND MESSAGE DISTRIBUTION function. It is divided into two parts, DECISION PROCESSES **440** used to determine available communications networks that will be used and MESSAGE HANDLING PROCESSES **470** used to send and receive messages over available communications networks.

The decisions **445**, **450**, **455**, **460** and **465** made in DECISION PROCESSES **440** use information saved in AVAILABLE NETWORKS & STATUS **315**, ACP **335**, PRIORITY PROCESSING INSTRUCTIONS **355**, SECURITY PROCESSING INSTRUCTIONS **365**, URGENCY PROCESSING INSTRUCTIONS **375**, and SIZE/BANDWIDTH PROCESSING INSTRUCTIONS **385**. These stored data items are used to select networks to be used for current requested message transactions.

TACNET SELECTED **445** determines availability of and criteria for using military tactical networks (examples are JTIDS, MIDS, MILSTAR, or others) using TACNET network layer protocols **180**.

A618 SELECTED **450** determines availability of and criteria for using various civil air-ground networks **258** and **260** of Fig.1, in accordance with protocols defined by ARINC specification number 618 **215** of Fig. 1.

A619 SELECTED **455** determines availability of and criteria for communicating with various civil end systems **265** and **270** of Fig.1, in accordance with protocols defined by ARINC specification number 619 , **170, 190** of Fig.1.

A656 SELECTED **460** determines availability of and criteria for communicating with a flight management system using interfaces **265** or **270** of Fig. 1, in accordance with protocols defined by ARINC specification number 656 **175**, **185** of Fig. 1.

ATN SELECTED **465** determines availability of and criteria for using various civil air-ground networks **258** and **260** of Fig. 1 in accordance with protocols defined by the ICAO ATN specification **195** through **210** of Fig. 1.

Processes **475, 480, 485, 490,** and **495** performed in MESSAGE HANDLING PROCESSES **470** use information saved in stored data **325, 335**, **400**, **410**, **420,** and **430**. NETWORK FAULTS **325**, ALERTS **430** and ACP **335** are used to automatically generate ad hoc messages reporting network faults, alerts and the overall communications performance

capability. END SYSTEM DATA **400**, TRENDS **410** and DECISION AIDES **420** are used to automatically generate ad hoc messages distributing this information to appropriate military agencies and/or organizations.

PROCESS MESSAGES OVER TACTICAL NETWORK **475** performs network management and message handling for available military tactical networks JTIDS/MIDS **280**, MILSTAR **285** or others **295** of Fig.1.

PROCESS MESSAGES OVER A618 NETWORK **480** performs network management and message handling for available civil air-ground networks such as VDR **258**, SDU **260**, HFDR **260**, MODE S **260** or others of Fig. 1, in accordance with protocols defined by ARINC specification number 618.

PROCESS MESSAGES OVER A619 NETWORK **485** performs network management and message handling for end systems **265**, **270**, **275** and **290** of Fig. 1, in accordance with protocols defined by ARINC specification number 619.

PROCESS MESSAGES OVER A656 NETWORK **490** performs network management and message handling for a flight management system in accordance with protocols defined by ARINC specification number 656.

PROCESS MESSAGES OVER ATN **495** performs network management and message handling for available civil air-ground networks such as VDR **258**, SDU **260**, HFDR **260**, MODE S **260**, or others of Fig. 1 in accordance with protocols defined by the ICAO ATN specification.

Major SmartBridge capabilities are Network Configuration and Status **305**, Message Routing Criteria **340**, Data Collection Agents **390,** and Network Management and Message Distribution **435**.

The process flow for Section 1 determining available network configuration and status **305** is illustrated in Fig.2a. SmartBridge will receive datalink network status from both military and civil communications equipment in the form of digital data words. SmartBridge will also receive datalink network configuration information from both military and civil communications equipment in the form of digital data words. SmartBridge will use this data for building an integrated status of available communication devices along with their configuration and capabilities for use in intelligent routing that will reduce crew workload and increase the end-to-end message delivery success. Health monitoring functions of SmartBridge will record and alert the crew of any faults detected from connected communications systems. Loss of connections will result in an alert to the crew along with an outgoing message over another available communication system informing

the ground or other vehicles of the communications downgrade. SmartBridge will also use this data to compute an ACP **335** indicator for the vehicle. With SmartBridge's understanding of the entire network configuration, it will be able to route outgoing messages over various networks using criteria built into message format or general downlink message conditions. Based on the network configuration, SmartBridge will differentiate between a secure and non-secure network and a military and non-military network, providing more robustness in message handling. SmartBridge will provide the conduit for uplink messages to military specific onboard applications **100**, **110**, **275** and **290** and civil applications **120**, **130**, **140**, **150**, **265** and **270** of Fig.1. This will allow datalink messages from ground-based communications infrastructures or other vehicles using the supported communications systems to be routed to supported applications (examples are a Link-16 message, secure ACARS message for military use, or a civil ATC clearance message).

The process flow for section 2 or determining message routing criteria **340** is illustrated in Fig. 2a. SmartBridge will analyze routing criteria against datalink messages to determine proper message handling responses. Output of the criteria evaluation will be used to route messages to particular communications systems or other equipment on the vehicle or in the ground-based communications infrastructure. SmartBridge will evaluate various routing criteria associated with each message based upon construction of

each message. Based upon results of criteria analysis, SmartBridge will execute routing operations to transmit messages to particular communications systems that can best achieve end results of getting messages to intended destinations, while at the same time meeting routing criteria requirements. The following list and descriptions are examples of integrated routing criteria that SmartBridge will use on datalink messages:

Priority **350** - SmartBridge will control message routing inside the system for all available networks. It will have the ability to prioritize messages scheduled for transmission. SmartBridge will differentiate message priority by definition of message requests and subsequently place messages ahead of or behind other messages to achieve desired operations. Prioritization will be established for each available network, as well as across all networks.

Security **360** - SmartBridge will be able to format and route messages to networks that provide both secure and non-secure communications. Messages will contain data that identify whether or not messages should go over a secure datalink path.

Urgency **370** - SmartBridge will recognize urgency flags that are contained in messages. SmartBridge will recognize various levels of urgency and respond accordingly by routing messages over the most

reliable datalink, moving messages ahead of other messages and adding formats to messages so receiving systems understand the level of urgency.

Size **380** - SmartBridge will recognize size of messages and route to the most efficient and cost-effective communications system. An example is that it is more cost-effective to transmit a large message over a VHF or HF link rather than a SATCOM link. Based on other routing criteria such as urgency, these large messages will be stored until a more cost-effective link is available and then transmitted at that time.

Bandwidth **380** - Due to varying communications systems and varying transmission speeds, SmartBridge will route to particular systems based on bandwidth requirements that are contained in messages. Data will be included in messages to inform SmartBridge what bandwidth is acceptable to use for its routing decision making.

The process flow for section 3 or executing data collection agents **390** is illustrated in Fig. 2a. SmartBridge will execute software algorithms that process incoming and outgoing messages to identify selected information to automatically formulate message and distribution instructions. Data collection agents will collect end system data from all available sources **395**, analyze the data for trends **405**, analyze any trends to determine decision aides **415**, and generate automatic alerts **425**. In addition, equipment health

data and mission data available from tactical datalinks and end systems will be collected. SmartBridge uses this data to automatically generate ATC messages per ARINC specification number 623 and RTCA DO-219, and AOC messages in accordance with ARINC specification numbers 620 and 702A. This data will also be used to prepare military unique AOC messages for command and control operations as well as for maintenance organizations. Table 1 provides an example list of automatically generated messages.

Table 1 - Automatically Generated AOC and ATC Messages

AOC Messages	**ATC MESSAGES**
Position Reports – Trigger Based	Position Reports – Trigger Based
Engine Parameter Report	Flight Plan Diversions due to Weather, Traffic
Maintenance Data Report	Altitude Clearances
Weapon Inventory Report	Air Traffic Information Service (ATIS) Reports based on Position downlink
Fuel Report	
Target Information Uplink	
Mission Route Modification	
System Performance Indicator	

The process flow for section 4 or Network Management and Message Distribution **435** is illustrated in Fig. 2b. SmartBridge will use network

configuration and status information **315**, ACP **335**, and various processing instructions **355**, **365**, **375** and **385** to manage operation of the available communications networks and make decisions on which active network to use for each specific message request. As each message request is being processed on a specific network, SmartBridge prepares ad hoc messages **470** using data collected by data collection agents **390**. These automatically generated messages **470** will then be sent out over active networks using pre-defined message routing criteria **340** and **440**. SmartBridge will also be capable of formatting each message in a number of different ways (using network protocols **170** through **215**), so receiving communications systems or end systems can understand and use the data. The following list and descriptions are network routing destinations that SmartBridge will interface with for delivering messages.

TACNET - When messages are transmitted over any supported military tactical network, SmartBridge will route messages to the Tactical Network layer **180**. This layer understands how to interface with these networks, allowing data to be transmitted to particular devices. SmartBridge provides specific destination system instructions based on routing criteria in the message and provides this information to the TACNET function **180**.

A618 - SmartBridge will route messages to the A618 network layer **215** upon evaluation of message content against routing criteria. This is used to route messages over civil communications systems. Secure messages can also be routed to this layer for use with compatible secure ACARS communications systems. Depending on the message routing criteria, this civil datalink connection can be used for military messages created by the onboard military applications **100**, **110**, **275** and **290**.

A619 - SmartBridge will route messages to other onboard end systems by evaluating message criteria and forwarding to the A619 network layer **170** or **190**. This is used when another system on the vehicle uses information received in uplink messages from the ground or other vehicles.

A656 - SmartBridge will route messages to the A656 network layer **175** or **185** upon evaluation of message content against routing criteria. This will consist of data received in uplink messages that SmartBridge provides to a flight management system.

ATN - SmartBridge interfaces with ATN applications to handle those message requests. SmartBridge will route any ATN type message from a military or civil ATN application to the required communications system.

Although the invention has been described in detail with particular reference to these preferred embodiments, other embodiments can achieve the same results. Variations and modifications of the present invention will be obvious to those skilled in the art and it is intended to cover in the appended claims all such modifications and equivalents. The entire disclosures of all references, applications, patents, and publications cited above, are hereby incorporated by reference.